

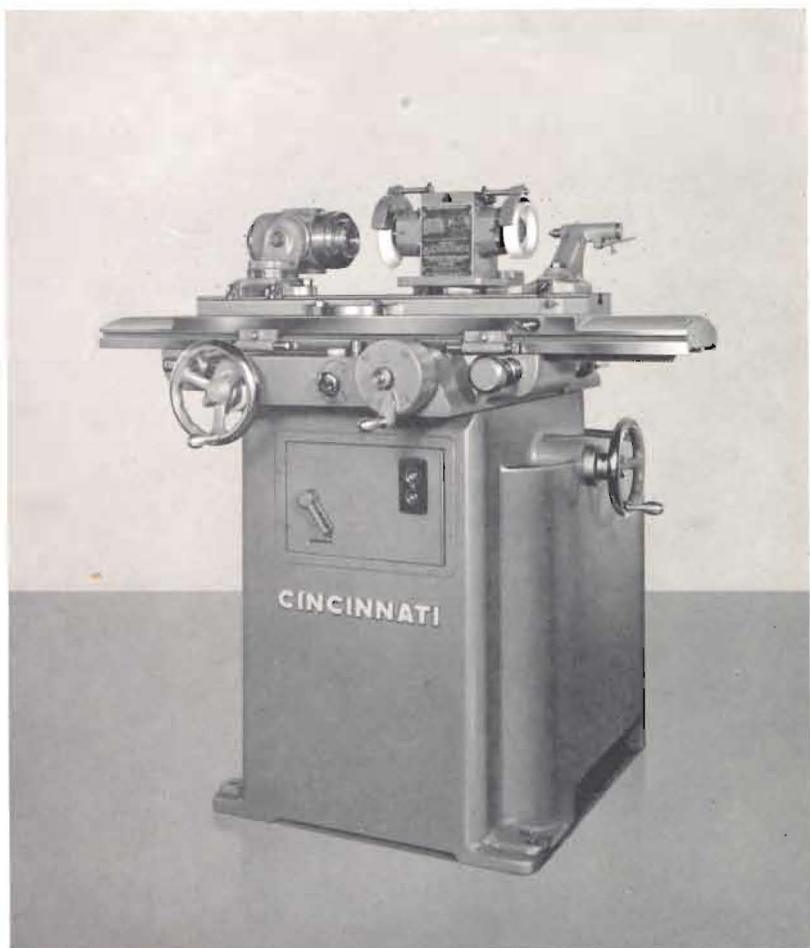
recommendations

FOR SHARPENING CARBIDE

MILLING CUTTERS



THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U. S. A.



• CINCINNATI No. 2 Cutter and Tool Grinder

RECOMMENDATIONS FOR SHARPENING CARBIDE MILLING CUTTERS

IN our application of carbide-tipped tools to production jobs, we have found that one of the most important factors that governs the successful use of these tools is the sharpening operation. The consistency of tool life and the success of the cutting operation stand in proportion to the care that is exercised in sharpening the cutter. Fine workmanship is a must in carbide cutter preparation.

How to grind carbides is no mystery; any person who is familiar with the ordinary cutter grinder has the general knowledge that is needed to sharpen carbide milling cutters. Still, *only if more than ordinary workmanship* is exercised, will the user of carbides be able to attain optimum results on the production line.

As in any grinding job, it is virtually impossible to lay down a set of hard and fast rules that govern all situations. These recommendations, then, propose a method based upon an effective and workable technique, developed in our shop, that produces all the requirements for successful cutter preparation. The following procedure is based on present carbide milling-cutter sharpening practice.

CARBIDE GRINDING DEPARTMENT

If at all possible, a separate department should be put aside for the exclusive sharpening of carbide milling cutters. When several cutter grinders are available, considerable set-up time can be saved by leaving one machine set-up for circle grinding, another for grinding the tooth face, and one or two others for grinding the clearance angles.

If a separate department is not warranted, care should still be taken to let only experienced carbide grinder hands handle the jobs. As the grinding of carbides requires considerable skill, it is imperative that these men be open-minded and receptive toward recommendations. Quite aside from all the other do's and don't's of carbide grinding, the operator should be

especially careful to avoid overheating the sintered carbide. Furthermore, he should make sure that all the defects and wear marks left on the tool from previous cutting operations have been removed. Only in this manner is it possible to obtain optimum results on the production line.

GENERAL EQUIPMENT REQUIRED

1. Cincinnati No. 2 Cutter and Tool Grinder and attachments.
2. Spot light mounted on grinder to provide concentrated illumination where needed.
3. **Wheels.** The diamond wheels recommended below are of the standard resinoid bond. The shape recommended for the cup wheel is one having a diamond section $\frac{1}{8}$ " wide by $\frac{1}{8}$ " thick mounted on the face of the wheel. The diamond grinding wheels should be mounted permanently on their collets; that is, once the wheel has been trued, it should not be removed from the collet for the remainder of its life. Cup wheels should be indicated for face runout and straight wheels for peripheral runout. This runout should be reduced to 0.00025" or less by scraping the backs of the hubs of the cup wheels or by radially shifting the straight wheels on their collets. The bore in the straight wheel has been left 0.005" oversize for this purpose.

a. **Flaring Cup Wheel for General Grinding and Finishing:** $3\frac{1}{2}$ " diameter, 150 to 180 grit, resinoid bond, 100 concentration.

b. **Flaring Cup Wheel for Grinding the Tooth Face:** 3" diameter, 150 to 180 grit, resinoid bond, 100 concentration.

Note: If desired, this wheel can be used for general purpose carbide grinding. If used for grinding the tooth face, it is usually placed on an extension collet.

The standard 3" flaring cup wheel has a $\frac{1}{2}$ " bore.

- c. **Roughing Wheel for Circle Grinding:**

In addition, a 6" diameter, $\frac{1}{2}$ " wide, 60 grit, vitrified bond, silicon-carbide wheel should be provided for circle grinding.

Note: It has been found that the expensive diamond wheel is not necessary for circle grinding operations.

4. Mist Type Coolant System (See Page 5).
5. A double ended diamond hand hone, 400 grit on one end and 500 grit on the other, vitrified bond, 100 concentration, $1/32$ " diamond depth.
6. A diamond wheel dressing stick. Pumice stone for dressing finishing wheels.
7. A magnifying glass, 10-20 power.

GENERAL RULES FOR SHARPENING CARBIDE MILLING CUTTERS

1. Sintered carbide tipped milling cutters are sharpened almost exclusively with *diamond wheels*, with the exception of circle grinding operations, where silicon-carbide wheels may be used. This type of grinding wheel cuts faster and will generate only a limited amount of heat, unless excessive pressure is applied to the work in grinding. High temperatures will cause heat cracks. Use of a light grinding pressure also avoids glazing of the wheel coating, and will reduce the need for frequent dressing of the wheel, thus lengthening its life. Cutters that have been correctly ground with diamond wheels of 220 grit or finer will show from two to three times greater life between grinds than tools finished by other means.
2. In sharpening sintered carbide tipped cutters, particular care should be taken to avoid the formation of heat cracks or "checks." This will occur if the feed rate is too fast, the amount of stock removed per pass is too great, or the grinding wheel is permitted to load or glaze. The amount of stock removed per pass should be from 0.00015" to a maximum of 0.0004", depending on the grit of the grinding wheel and the type of operation. More stock can be removed per pass when *rough grinding*, and correspondingly less stock should be removed when *finish grinding*. The cutter tip should be fed past the wheel by hand at rate of about 50" per minute in roughing and about 10" to 20" per minute in finishing.
3. The selection of a diamond grinding wheel is governed by the type of operation, the speed available in the machine, and the degree of finish desired. With a wheel of 80 to 150 grit, it is comparatively easy to rough grind for stock removal. An excellent cutting edge can be obtained with 180 to 240 grit wheels (Figure 1), and for special cases, a mirror finish can be produced with 320 to 500 grit wheels. The surface speed of the grinding wheel is generally 5000 to 5500 ft. per minute.

A milling cutter with clean cutting edges and a high finish, free from burrs and grinding marks, will have more efficient cutting action, produce a better quality of finish on the machined surface, and last longer than a cutter with edges showing a poor finish. If not properly ground, the cutting edge appears as an irregular saw-tooth shape when viewed under the microscope (Figure 1).

4. *Check diamond wheels for true running.* True running is essential with diamond wheels because they are expensive, and the rela-

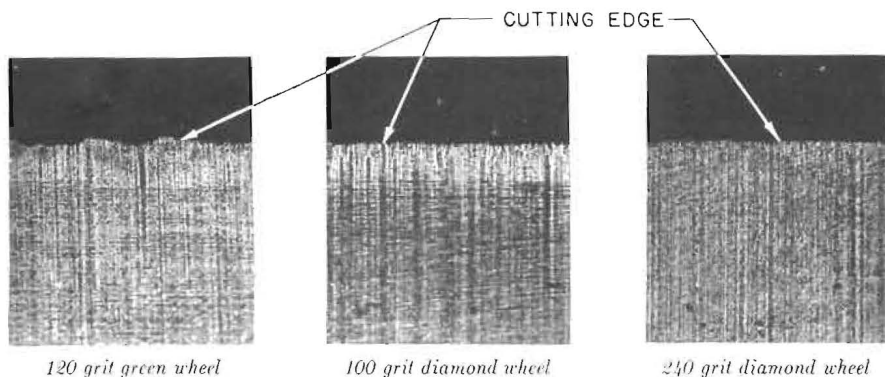


Figure 1 — Photomicrograph showing the condition of the cutting edge of sintered carbide tips ground with different kinds of grinding wheels. Magnified 100 diameters.

tively thin diamond coating would quickly be worn away and wasted by ordinary truing. To obtain true running, diamond wheels are mounted on tapered bushings. They should be mounted on the spindle of the cutter grinder with special care and checked for true running by means of a dial indicator.

5. Do not grind into the body of the cutter with a diamond wheel, as this will cause the wheel to load up rapidly. The carbide tips should project 0.040" to 0.060" beyond the cutter body after the original brazing operation. Grinding wheel clearance should be provided in the original body design. Ample wheel clearance also should be provided for the face of the tooth. When the carbide has been ground down to such an extent that the cutter body interferes with the free action of the grinding wheel, the carbide tips should be set out again or replaced.
6. The grinder operator should use a magnifying glass to examine the carbide both before grinding and at intervals during the grinding operation. All cracks and flaws in the carbide should be ground away in the roughing operation. All the crater and abrasion marks produced in cutting must be removed in grinding or cutter life will suffer considerably.
7. After the grinding operation, the teeth should be indicated for run out. In addition, the clearance and body interference should be checked carefully. These latter two steps are especially important for small diameter cutters and radius cutters.
8. *Hone the face and the land.* After the grinding has been completed, the cutter should be inspected and the face and land honed with a 400 or 500 grit diamond hone.

9. *Sharpen cutters WET.* Wet grinding is preferred when sharpening with diamond wheels. Strong alkaline solutions should be avoided, since they are injurious to bakelite bonding. The wick-and-oil cup method of moistening the face of the wheel is still largely used. Cim-cool, a product of the Cincinnati Milling Products Division of The Cincinnati Milling Machine Co. is recommended as a coolant.

A more efficient method, which eliminates the disadvantages of splashing the cutter and the machine and obstructing the view of the operator, is that shown in Figure 2 applied to a cutter grinder.

This unit consists of a special *wheel guard* which surrounds the grinding wheel, but without obstructing the view during the re-sharpening operation. The guard is connected by flexible tubing to a coolant tank, a pump and a suction unit.

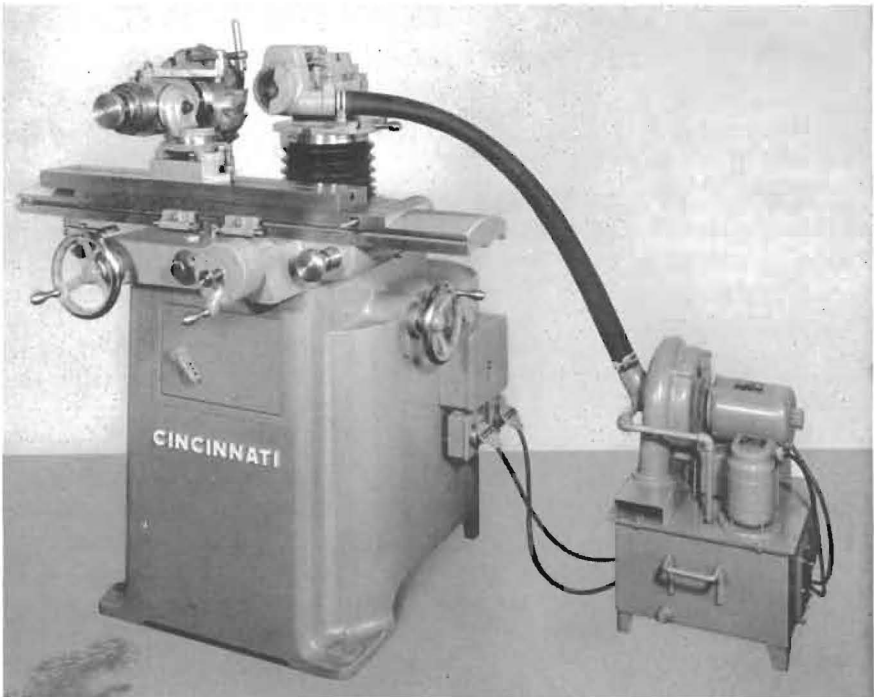


Figure 2 — Coolant system applied to a cutter grinder to wet grind carbide cutters with diamond-impregnated wheels.

As the coolant strikes the diamond wheel, a mist is created, which wets the cutter and the grinding wheel, and is then sucked back into the coolant tank through a large diameter flexible tube.

The advantages of wet grinding over the dry method are:

1. Increase in the life of expensive diamond wheels by avoiding overheating.

2. Better finish of the ground surfaces of the carbide tips.
 3. Resharpener time is reduced because more carbide stock can be removed per pass than with the dry method.
10. During the grinding operation, hold the cutter in the same manner as it will be held on the milling machine; i.e. face mills should be bolted to the flange of the face mill arbor, shell end mills should remain on their arbors during the grinding operation, etc.
- Note: Some users of carbides find it more economical to employ inserted-tooth cutters; in this case, wear marks are removed by grinding on the lands only and not on the tooth face. (See page 12).
11. After the complete grinding operation, the cutter teeth should be examined carefully with a 10-20 power magnifying glass; if any defects on the cutting edges show up at this time, the cutter must be re-sharpened. The surface finish on a carefully ground tooth should be below 5 micro-inches.

DIAMOND WHEELS

The shapes of diamond wheels used in grinding and producing an especially fine finish on sintered carbide tipped milling cutters are shown in Figure 4. These grinding wheels have a thin diamond coating on the *face*. Plain cup wheels of from 3" to 10" in diameter predominate in general grinding operations.

Diamond wheels of the flaring cup type are also available with the diamond coating located on the *periphery* (Figure 3). These wheels permit a more economical use of the diamond coating and less waste when dressing the wheel. They also provide freer and cooler cutting action than the usual flaring cup type grinding wheel in which the diamond coating is located on the face of the wheel.

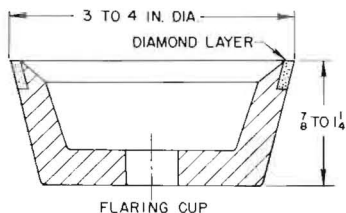


Figure 3—Diamond wheel with diamond coating located on periphery.

The bonding material usually employed in diamond wheels is bakelite or synthetic resin, but metal-bonded wheels, a product of powder metallurgy, and vitrified bonded wheels are also used.

Diamond concentration is of three grades—25, 50 and 100. In a diamond wheel marked: (100-B 100-1/8) the first number indicates the grit size, the letter stands for the bond (B-resinoid, M-Metal), the next number shows the diamond concentration, and the final figure gives the depth of the diamond section.

Diamond wheels are made in grit sizes from 80 to 500 and classified as follows:

Coarse.....	80 to 150 grit
Medium.....	180 to 240 grit
Fine.....	320 to 500 grit

Within this range, it is comparatively easy to rough grind for stock removal with a coarse grit wheel, to obtain an excellent cutting edge with a medium grit wheel, and, for special cases, to produce a mirror finish with a fine grit wheel.

DRESSING DIAMOND WHEELS

Diamond wheels are dressed with a soft aluminous abrasive of 80 to 120 grit, or pumice stone, passed slowly across the face of the wheel with a light, even pressure. This should be done at about three-quarters of the operating speed. The wheel should be greased with paraffin while being dressed.

Diamond wheels of the cup or dish type may also be resurfaced by rubbing them on a flat plate sprinkled with silicon carbide powder of 180 to 220 grit. This operation can be performed dry. It should be done with a circular sweep of the arm and a light, even pressure, changing the position of the wheel in the hand frequently to insure uniformity in dressing.

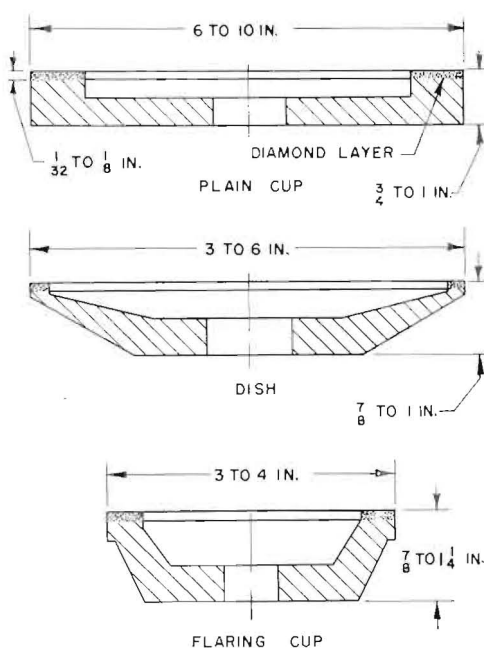


Figure 4 — Most commonly used shapes of diamond wheels having resinoid or metal bonding.

Specifications of Grinding Wheels for Sharpening Carbide Cutters

CUTTER MATERIAL	OPERATION	GRINDING WHEEL			
		Abrasive Material	Grain Size	Grade	Bond
Sintered Carbide	Roughing after Brazing	Silicon Carbide	60	G	Vitrified
	Roughing	Diamond	100	*	Resinoid
	Finishing	Diamond	Up to 500	*	Resinoid

*Not indicated in diamond wheel markings.

MILLING CUTTER ELEMENTS

Milling cutters are composed of a number of *elements* (Figure 5), which contribute in varying degree to the removal of material from the work-piece. Not all are necessarily found in any one cutter, their presence being determined by the type of cutter, the material being machined, the method of milling employed, feed and speed rates and other factors.

Milling cutter elements must conform to certain requirements, which, either by experimentation or experience, have been found necessary to increase the efficiency of the cutter, provide longer cutter life, improve cutter performance and produce a superior quality of finish on the milled surface. Only those elements which are the responsibility of the cutter grinder operator and the cutter sharpening department will be considered.

Rake and Corner Angles. In *peripheral milling cutters* such as slab mills, slotting cutters, saws, etc., tipped with sintered carbide the rake angle is generally defined as the angle in degrees measuring the deviation of the *tooth face* from a radial line to the cutting edge. This is the *radial rake angle* (Figure 5). Cutters of this type generally have *negative radial rake angles* of 5° for soft low carbon steel to 10° or more for alloy steel, and *positive axial rake angles* of 5° to 10°, respectively, which in some cases may be 0° in slotting cutters and saws. On soft materials such as free-cutting aluminum alloys, positive rake angles of 10° to 20° are often used.

In *face milling cutters* tipped with sintered carbide the teeth are inclined with respect to both radial and axial lines (Figure 5). These angles are called *radial* and *axial rake angles*, respectively. The radial and axial rake angles may be *positive*, *zero* or *negative*. In face mills great variation is found in the value of the radial and axial rake angles in relation to the grade of sintered carbide material used, the material being cut, the value of the corner angle and setup conditions.

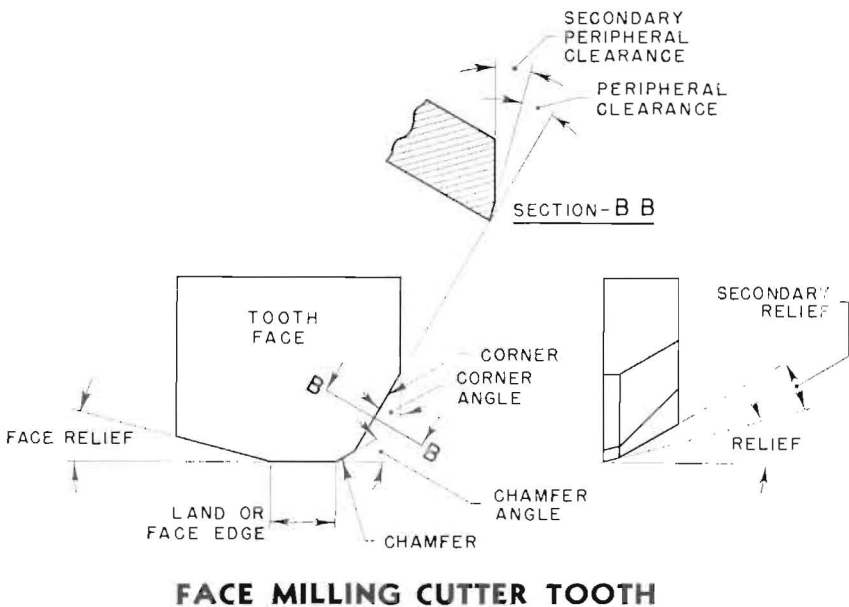
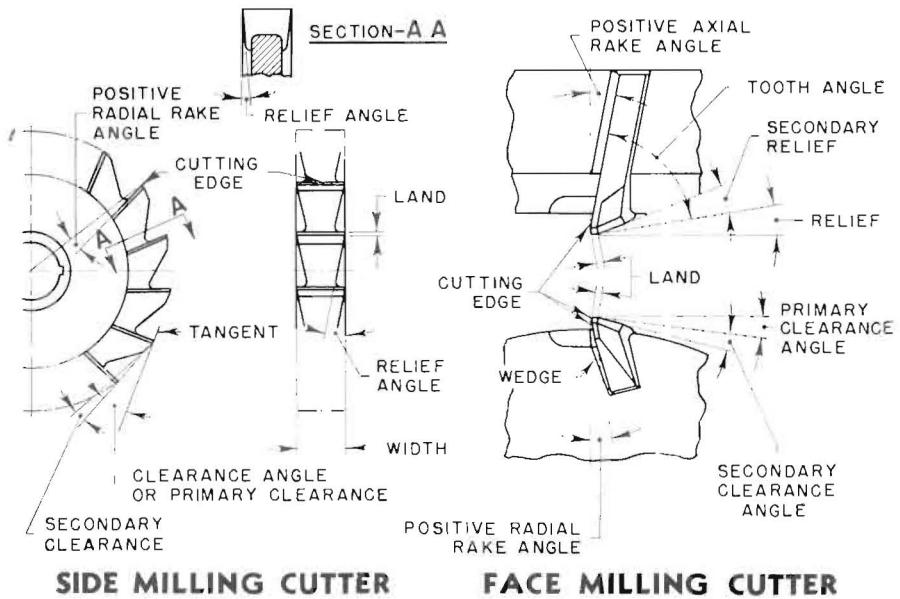


Figure 5—Nomenclature of milling cutter elements.

Positive radial and axial rake angles are commonly used when milling cast iron with face mills having zero corner angles and a small chamfer or radius. With a *large corner angle*, positive axial angles with either positive or negative radial rake angles are used with a 60° single corner angle or a double corner angle of 60° - 45° combination. This is done to increase cutter life and reduce work break-out and wear on carbide tips caused by scale.

When face milling steel with zero corner angle cutters, negative radial and axial rake angles are used; but with cutters having *large corner angles*, a combination of negative radial and positive or negative axial rake angles is employed, depending upon the rigidity of the set-up. Under good set-up conditions, the combination of negative radial and positive axial rake angles is preferred.

Land. In *peripheral milling cutters* (Figure 5), the land is a narrow surface back of the cutting edge which results from providing the clearance angle. The width of this land varies from $1/64"$ in small diameter cutters to $1/16"$ for cutters of larger diameter.

In *face mills* the term "land" (Figure 5) is often used in referring to that portion of the cutting edge which is parallel to the face of the cutter. This is more correctly called the *face edge*. The length of the face edge may vary between broad limits, but usually should be somewhat greater than the feed per revolution. For general purpose operations, a $1/8"$ length is ample for large diameter and a $1/16"$ length for small diameter face mills.

Clearance Angles. The clearance angle (Figure 5) is that angle provided back of the cutting edge and should be carefully selected in all types of cutters. The value of the clearance angle plays an important role in obtaining good cutter performance, high cutting efficiency and long cutter life between grindings.

It is desirable in all cases to use a clearance angle *as small as possible*, so as to leave more metal for heat dissipation, and insure maximum strength of the cutting edge. Any clearance angle greater than required by the cut will weaken the cutting edge, and may cause failure under heavy duty operation. It will also increase the likelihood of "chatter," result in a poor finish on the machined surface, and reduce cutter life.

The clearance angle is sometimes referred to as the *primary clearance* since a *secondary* is usually provided when resharpener these cutters. Repeated sharpening of the cutter eventually increases the width of the land to a point where interference with the surface being milled may

develop. To eliminate this interference and maintain the desired width of land without weakening the section of the tooth, a secondary clearance is ground on the back of the tooth. This angle is usually 3° larger than the primary clearance angle.

Since the cutting edge in face mills is on both the periphery and face of the cutter, the clearance angle must be ground along the complete contour of the cutting edge. This also applies to face mills having a corner or round nose.

For general purpose work, milling cutters from $\frac{1}{8}$ " to 3" in diameter have clearance angles from 13° to 5° , respectively, and decreasing proportionately as the diameter increases. In cutters over 3" in diameter, cutter manufacturers usually provide a clearance of 4° to 5° . The land is usually about $1/64$ ", $1/32$ " and $1/16$ " wide in small, medium and large diameter cutters, respectively.

The term *relief* (Figure 5) in cutters such as side mills, face mills and metal slitting saws, refers to the angle provided radially on the *sides* or *face* of the cutter to reduce or eliminate binding and rubbing on the work. The most commonly used values of relief angles are from 3° to 5° in milling cutters and from 1° to 2° in saws.

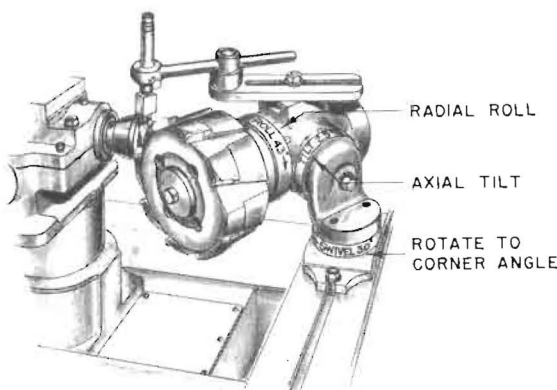
Recommended Clearance Angles

TYPE OF CUTTER	PRIMARY CLEARANCE ANGLES								
	<i>Periphery</i>			<i>Corner</i>			<i>Face</i>		
	<i>Steel</i>	<i>C. I.</i>	<i>Al.</i>	<i>Steel</i>	<i>C. I.</i>	<i>Al.</i>	<i>Steel</i>	<i>C. I.</i>	<i>Al.</i>
Face or side.....	4-5°	7°	10°	4-5°	7°	10°	3-4°	5°	10°
Slotting.....	5-6°	7°	10°	5-6°	7°	10°	3°	5°	10°
Saw.....	5-6°	7°	10°	5-6°	7°	10°	3°	5°	10°

True Clearance. The true clearance on the corners of face mills is the resultant of the clearance angles and is measured in the axial and radial planes. In order to get the true clearance on the corners it is only necessary to roll and tilt the workhead of the cutter grinder the amounts shown in the following table for the particular corner angle being ground.

THE CINCINNATI MILLING MACHINE CO.

To use the table select the desired true clearance angle and corner angle. At the horizontal and vertical intersection of these values read correct settings for radial roll and axial tilt. For example: for 5° true clearance and 30° corner angle, the radial roll is 4.3°; the axial tilt is 2.5°.



CORNER ANGLE

	5°		10°		15°		20°		22½°		25°		30°		35°		40°		45°		
	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	Radial roll	Axial tilt	
½°	0	0.5	0.1	0.5	0.1	0.5	0.2	0.5	0.2	0.5	0.2	0.5	0.3	0.4	0.3	0.4	0.3	0.4	0.4	0.4	½°
1°	0.1	1.0	0.2	1.0	0.3	1.0	0.3	0.9	0.4	0.9	0.4	0.9	0.5	0.9	0.6	0.8	0.6	0.8	0.7	0.7	1°
1½°	0.1	1.5	0.3	1.5	0.4	1.5	0.5	1.4	0.6	1.4	0.6	1.4	0.8	1.3	0.9	1.2	1.0	1.1	1.1	1.1	1½°
2°	0.2	2.0	0.3	2.0	0.5	1.9	0.7	1.9	0.8	1.8	0.8	1.8	1.0	1.7	1.2	1.6	1.3	1.5	1.4	1.4	2°
2½°	0.2	2.5	0.4	2.5	0.6	2.4	0.9	2.4	1.0	2.3	1.1	2.3	1.2	2.2	1.4	2.1	1.6	1.9	1.8	1.8	2½°
3°	0.3	3.0	0.5	3.0	0.8	2.9	1.0	2.8	1.2	2.8	1.3	2.7	1.6	2.6	1.7	2.5	1.9	2.4	2.1	2.1	3°
3½°	0.3	3.5	0.6	3.4	0.9	3.4	1.2	3.3	1.3	3.2	1.5	3.2	1.8	3.0	2.0	2.9	2.3	2.7	2.5	2.5	3½°
4°	0.3	4.0	0.7	3.9	1.0	3.9	1.4	3.8	1.5	3.7	1.7	3.6	2.0	3.5	2.3	3.3	2.6	3.1	2.8	2.8	4°
4½°	0.4	4.5	0.8	4.4	1.2	4.3	1.5	4.2	1.7	4.2	1.9	4.1	2.3	3.9	2.6	3.7	2.9	3.5	3.2	3.2	4½°
5°	0.4	5.0	0.9	4.9	1.3	4.8	1.7	4.7	1.9	4.6	2.1	4.5	2.5	4.3	2.9	4.1	3.2	3.8	3.5	3.5	5°
5½°	0.5	5.5	1.0	5.4	1.4	5.3	1.9	5.2	2.1	5.1	2.3	5.0	2.8	4.8	3.2	4.5	3.5	4.2	3.9	3.9	5½°
6°	0.5	6.0	1.0	5.9	1.6	5.8	2.1	5.6	2.3	5.6	2.5	5.4	3.0	5.2	3.5	4.9	3.9	4.6	4.3	4.3	6°
6½°	0.6	6.5	1.1	6.4	1.7	6.3	2.2	6.1	2.5	6.0	2.8	5.9	3.3	5.6	3.8	5.3	4.2	5.0	4.6	4.6	6½°
7°	0.6	7.0	1.2	6.9	1.8	6.8	2.4	6.6	2.7	6.5	3.0	6.4	3.5	6.1	4.0	5.8	4.5	5.4	5.0	5.0	7°
7½°	0.7	7.5	1.3	7.4	2.0	7.3	2.6	7.0	2.9	6.9	3.2	6.8	3.8	6.5	4.3	6.2	4.8	5.8	5.3	5.3	7½°
8°	0.7	8.0	1.4	7.9	2.1	7.7	2.8	7.5	3.1	7.4	3.4	7.3	4.0	6.9	4.6	6.6	5.2	6.2	5.6	5.6	8°
9°	0.8	9.0	1.6	8.9	2.4	8.7	3.1	8.5	3.5	8.3	3.8	8.2	4.5	7.8	5.2	7.4	5.8	6.9	6.4	6.4	9°
10°	0.9	10.0	1.8	9.9	2.6	9.7	3.5	9.4	3.9	9.3	4.3	9.1	5.1	8.7	5.8	8.2	6.5	7.7	7.1	7.1	10°
11°	1.0	11.0	1.9	10.8	2.9	10.6	3.8	10.4	4.3	10.2	4.7	10.0	5.6	9.6	6.4	9.1	7.1	8.5	7.8	7.8	11°
12°	1.1	12.0	2.1	11.8	3.2	11.6	4.2	11.3	4.7	11.1	5.2	10.9	6.1	10.4	7.0	9.9	7.8	9.3	8.6	8.6	12°
13°	1.2	13.0	2.3	12.8	3.4	12.6	4.5	12.3	5.1	12.1	5.6	11.8	6.6	11.3	7.6	10.7	8.5	10.0	9.3	9.3	13°
14°	1.2	14.0	2.5	13.8	3.7	13.5	4.9	13.2	5.5	13.0	6.0	12.7	7.1	12.2	8.1	11.5	9.1	10.8	10.0	10.0	14°
15°	1.3	15.0	2.7	14.8	4.0	14.5	5.3	14.2	5.9	13.9	6.5	13.7	7.6	13.1	8.7	12.4	9.8	11.6	10.7	10.7	15°
	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	Radial roll	
	85°	80°	75°	70°	67½°	65°	60°	55°	50°	45°											

CORNER ANGLE

• Face mill corner clearance angle settings

SHARPENING A CARBIDE-TIPPED FACE MILL

Now that the general recommendations have been covered, this information will be applied to a specific job: namely, the sharpening of a carbide-tipped face mill. The following represents a chronological order of the required procedures. The recommendations are based on the use of the best grinding wheels and equipment now commercially available.

Sharpening a Face Mill after new tips have been brazed into place:

- a. Circle grind the periphery, the face, and, finally, the corner angle. Use a 60 grit silicon-carbide straight wheel, 6" diameter, $\frac{1}{2}$ " wide.
- b. Grind the face of the carbide tip. Set the tooth rest behind the projection of the carbide tooth after first filing all excess braze off the carbide. After the tooth has been adjusted for its proper rake, this rake is maintained by feeding the tooth rest so as to rotate the

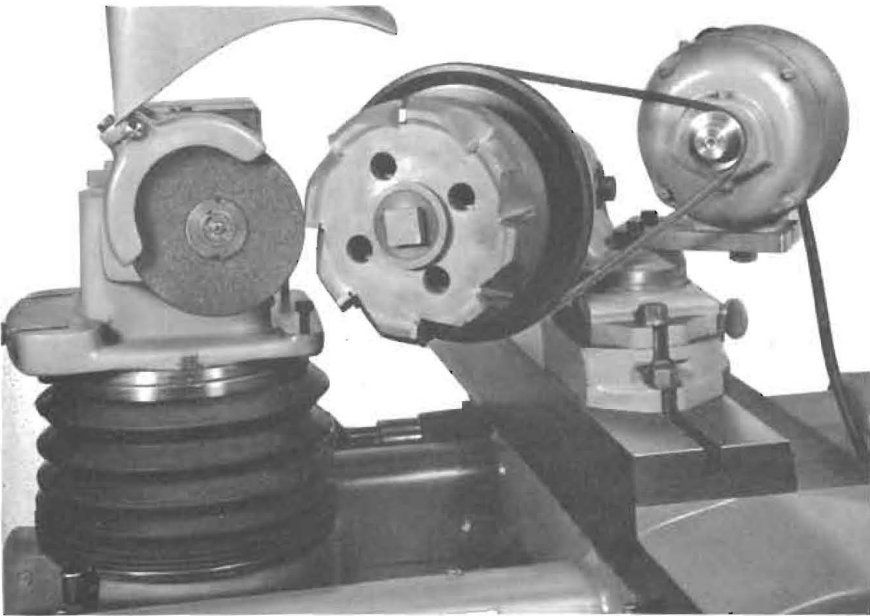


Figure 6 — Circle grinding set-up.

- cutter. In general, one tooth can be ground completely before passing on to the next tooth. Care must be exercised to prevent overheating of the carbide during the grinding operation.
- c. Grind the primary peripheral land. If this land should be too long, grind a secondary land.
 - d. Grind the clearance on the cutter face. If the face angle is less than 1° , grind a secondary face relief. The flat portion of the face cutting edge should exceed the feed per revolution by approximately 25 per cent.
 - e. Grind the clearance lands on the corner angle.
 - f. Check the run out on the periphery, the corner, and the face using a $1/10,000''$ indicator. And at the same time, make certain that no part of the cutter body projects beyond the cutting edge. It is desirable that run-out be kept to $0.0005''$ for cutters up to 6" and $0.0010''$ for cutters up to 12" in diameter.

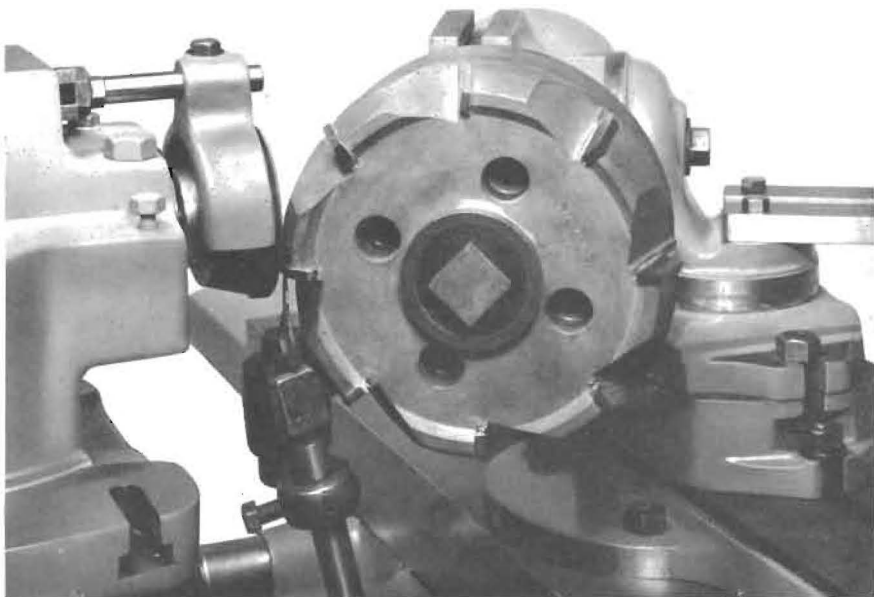


Figure 7 — Grinding the clearance land on the periphery.

- g. If the cutter is to be used for the milling of steel, bevel the cutting edges $0.002'' \times 45^\circ$ by hand with a diamond hone.
- h. Inspect the cutter teeth with a magnifying glass, making certain that no defects are present on the cutting edges; store the cutter in its box.

STORING AND HANDLING OF CUTTERS

Each cutter, when not in use, should be stored in a sturdy wooden box. More cutters are broken through negligence than through wear and overload during the cutting operation. For this reason, the cutter should remain in its box during transportation between toolroom and milling machine.

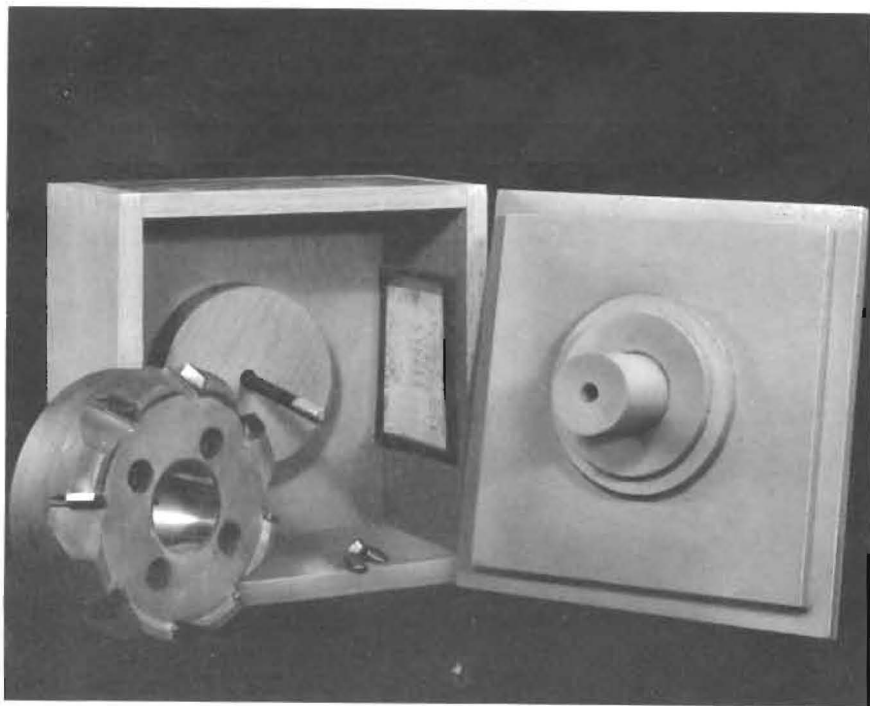


Figure 8 — Cutter should be stored in a sturdy wooden box.

Cutters may be given added protection by coating the carbide tips and adjacent surfaces with a plastic. In this manner, a tough, skin-tight protective film is formed over the tooth surfaces which can be peeled off readily the next time the cutter is used.

MARKING OF CUTTERS

The cutter's serial number should be stamped on each cutter body. Furthermore, an appropriate record card, providing the history of each cutter, should be placed in the box. Listed below is some of the information that should appear on the card:

- a. Axial rake angle
- b. Radial rake angle
- c. Corner angle
- d. Land or face edge
- e. Clearance angle
- f. Grade of carbide
- g. Date of each grind

CARBIDE CUTTER CARD											
Serial No.					Tool No.						
Cutter Type					Teeth			Make			
Diameter			Hand			Bore					
Corner Angle			Axial Rake			Radial Rake					
Body Thickness			Body Mat'l			Tip Size					
Grade of Carbide					/ / / / / / / / / /						
Chamfer											
Land or Face Edge											
Face Angle											
Face Relief											
Peripheral Clearance											
Tips Replaced											
Tips Reset											
Grinding Time (Hrs.)											
Date Ground					/ / / / / / / / / /						
Grind	1	2	3	4	5	6	7	8	9	10	

• Cutter grinding record

This information will serve both to identify the cutter and to instruct the cutter grinder operator in the rake angle setting.

OTHER CINCINNATI MACHINES

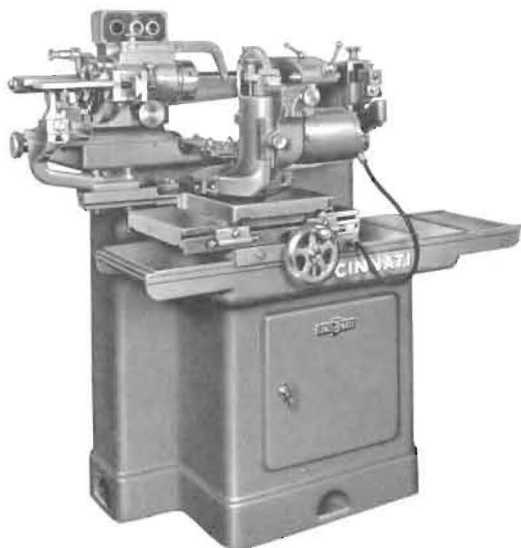
complementary to

CINCINNATI No. 2 CUTTER AND TOOL GRINDER

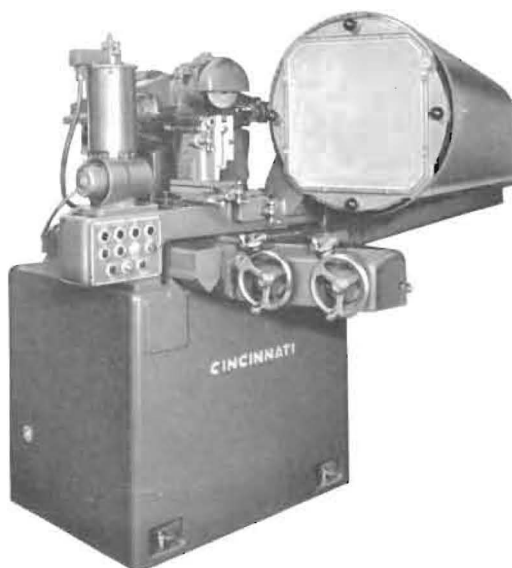
Monoset Cutter and Tool Grinder is particularly useful for quickly preparing special cutters. Cutters of the formed profile or contour ground type of tooth can be handled by the Contour Cutter Sharpening Machine. Accurate profile shapes of small carbide cutter tips and lamination die parts can be effectively ground on Projecto-Form Grinding Machines.



Monoset Cutter and
Tool Grinder



Contour Cutter
Sharpening Machine



Projecto-Form
Grinding Machine

PATENT NOTICE — The machines and attachments illustrated and described in this booklet are protected by issued and pending United States and Foreign patents. The design and specifications of the machines illustrated herein are subject to change without notice.



THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U. S. A.

Publication No. M-1714-1

Printed on 12-10-54
AM 11-10-54